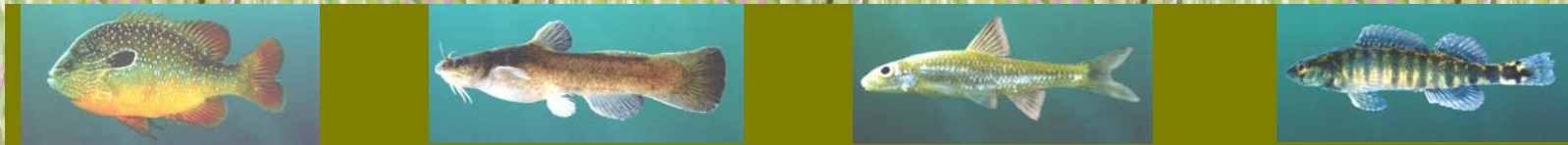


A Multivariate Approach to Source Identification of Biological Impairments in Aquatic Communities: A Case Study on the Limberlost Watershed, Jay County, Indiana



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Introduction

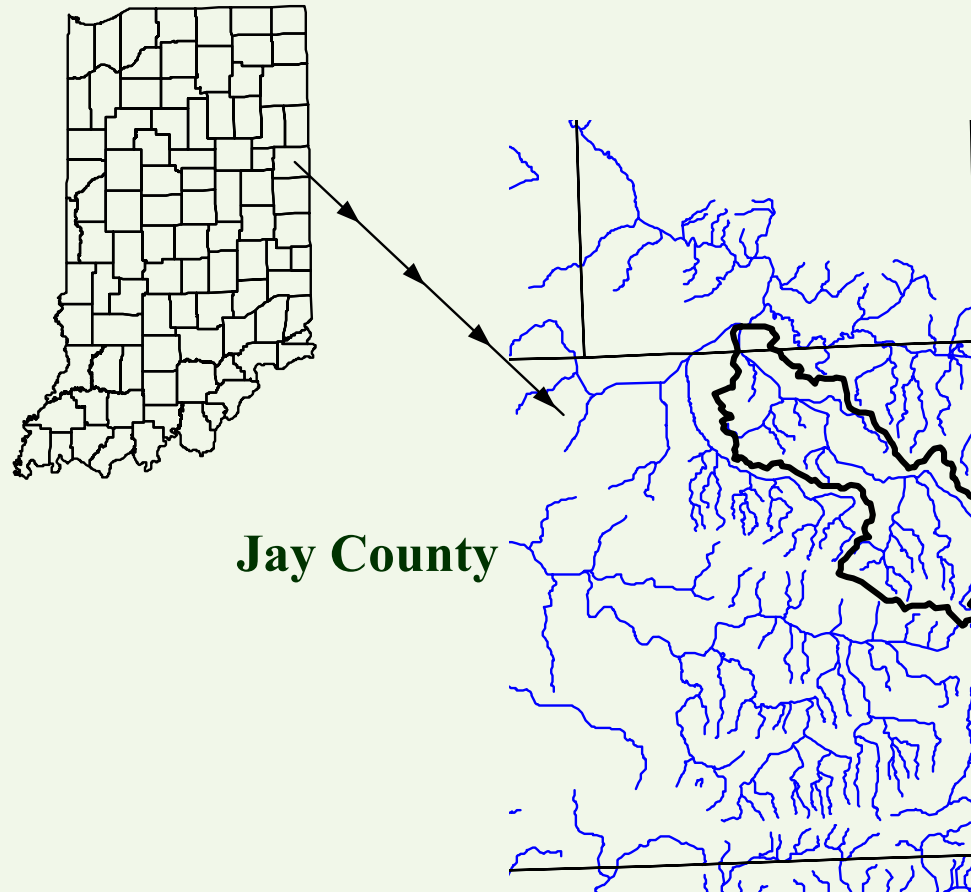
- Biological monitoring has proven to be a reliable and accurate method of evaluating the attainment of use designations
 - IDEM probabilistic surface water monitoring strategy
 - Application of biological field data for source identification of observed aquatic life impairments has been limited
 - Aquatic life criteria have been the benchmark for predicting and judging aquatic life impairments (i.e. numeric aquatic life criteria, waste load allocations, total maximum daily load, etc.)
 - This assumes that existing criteria are sufficiently protective, and that violations of these criteria will be discovered through intermittent chemical sampling and analysis
- 



Introduction/Objective

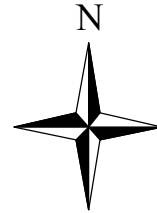
- Biological impairment can result from slightly elevated contaminant concentration, synergetic effects or sporadic spikes for which no numeric criteria violations occur
 - Without concurrent biological data for comparison statistically defensible causal or correlative conclusions are impossible
 - The objective of this study was to use a formal evaluation process utilizing multivariate techniques to provide statistically defensible causal conclusions for the biological impairment (303(d) listed) in Limberlost Creek and its tributaries
- 

Study Area



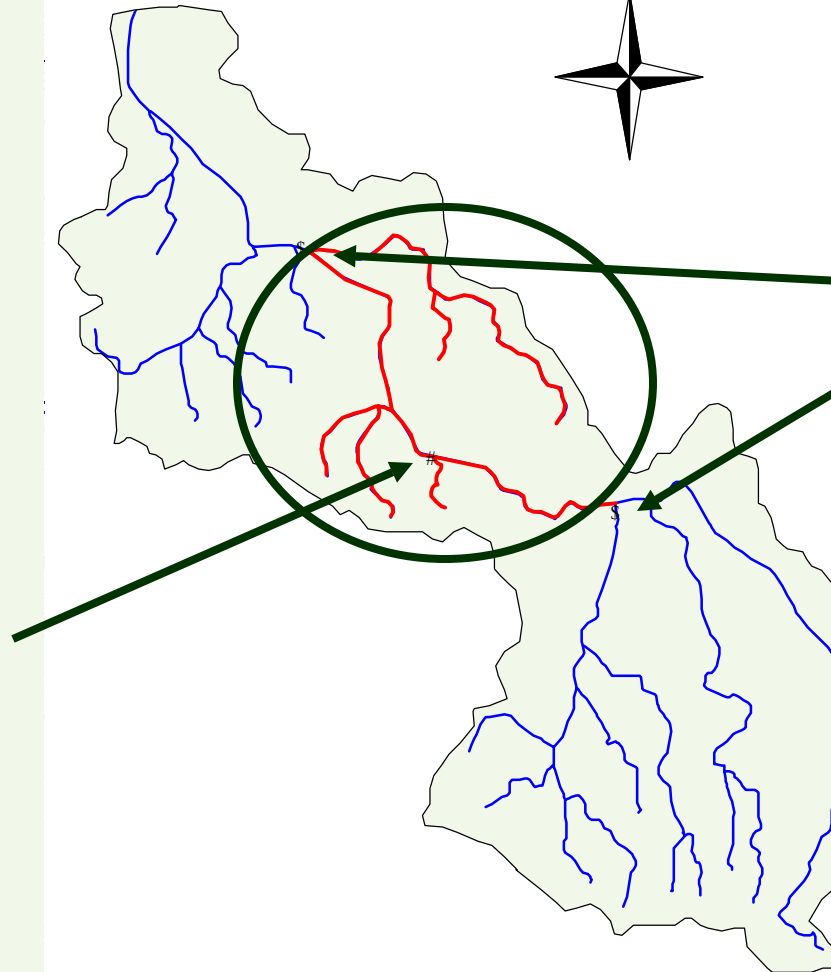
**Located over the
Trenton oil field
discovered in 1887**

**Stream segment listed
on the 2002, 303(d) List**




1991 macro. sites

**1998 probabilistic
fish site**





Sampling Methods

- Site Selection
 - All bridge crossings within the watershed (sampled once in June and again in August 2003)
 - Fish
 - Long-line (Smith-Root 2.5 GPP) and backpack (Smith-Root Model 15-C) electrofishing sampling a minimum of 50 meters and a maximum of 15X average stream width
 - Chemistry
 - Grab samples
 - Metals, nutrients, general chemistry (Indiana State Department of Health)
 - Habitat
 - Qualitative Habitat Evaluation Index (QHEI)
- 



Statistical Methods

- Data Transformation and Normalization
 - Percent relative abundance (Fish data for Cluster analysis)
 - Percent of range (Habitat, Chemistry & IBI Metrics)
- T-test
 - All parameters for seasonal interaction (June v/s August)
- Numerical Classification Analysis
 - Identification and graphical representation of patterns within normalized fish community data
 - Euclidean Distance Similarity Matrix for Cluster analysis using Wards Method to create dendograms

Statistical Methods Cont.

- ANOVA
 - Test physiochemical variables as predictors of fish community structure identified through cluster analysis
 - Tukey HSD post-hoc analysis
- Visual Presentation
 - Box and whisker plots (mean \pm SE)
 - groups identified by cluster analysis
 - Concentration pleths
 - Grid data matrix using Kriging method
 - Spline smooth grid inserting 5 columns and rows between each point



Chemistry Results

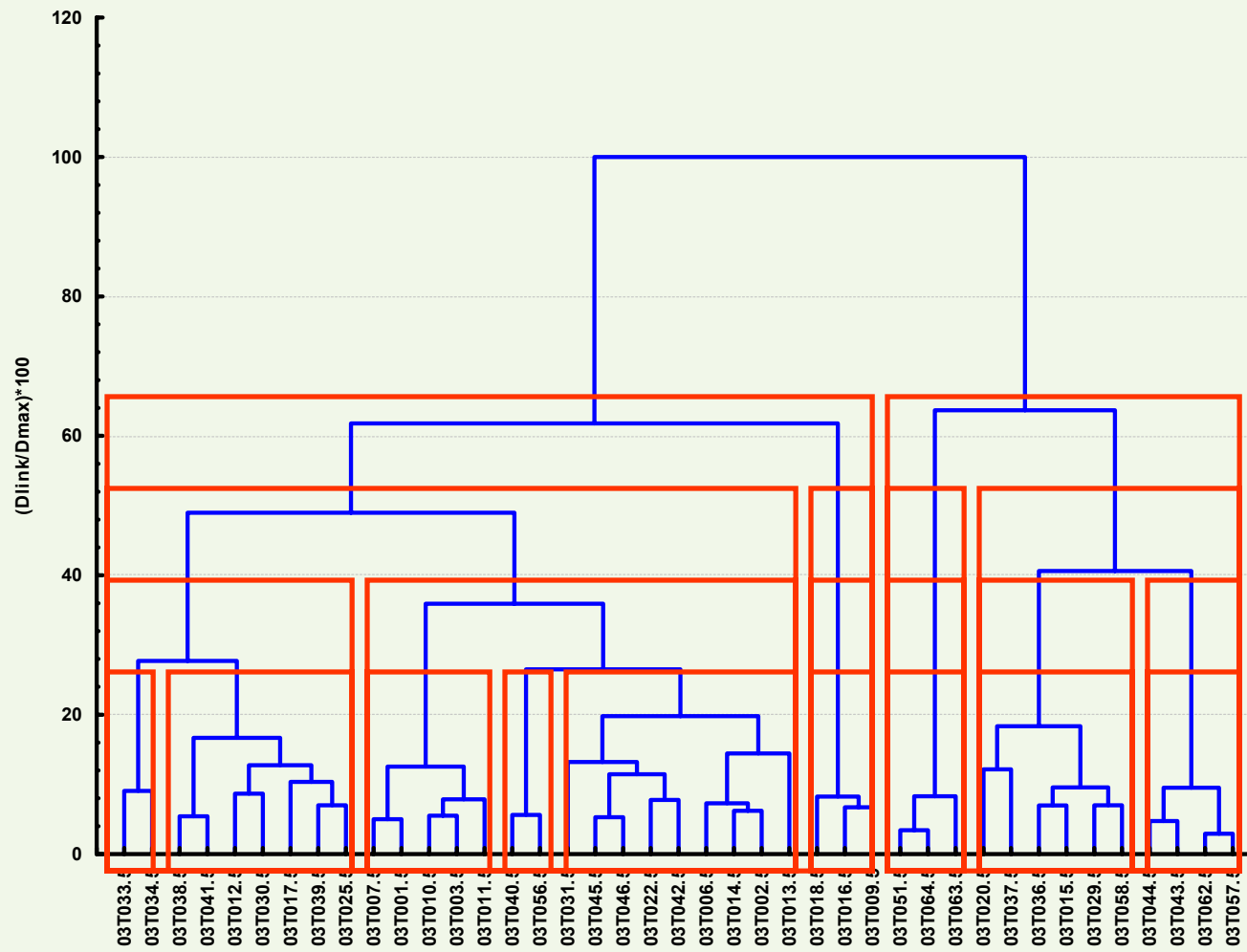
- Three chemical variables violated aquatic life criteria in June
 - Sulfate (1 violation) - general criteria for all waters (GC)
 - Chloride (1 violation) - chronic aquatic life criteria (CAC)
 - Ammonia (1 violation) - CAC
- Three chemical variables violated aquatic life criteria in August
 - Sulfate (5 violations) - GC
 - Chloride (5 violations)m - CAC
 - Ammonia (3 violations) - CAC



T-test Results

- 21 physiochemical variables demonstrated a significant difference between sampling season
 - Most notably IBI scores were significantly lower in June then in August
- Data from both June and August were analyzed separately

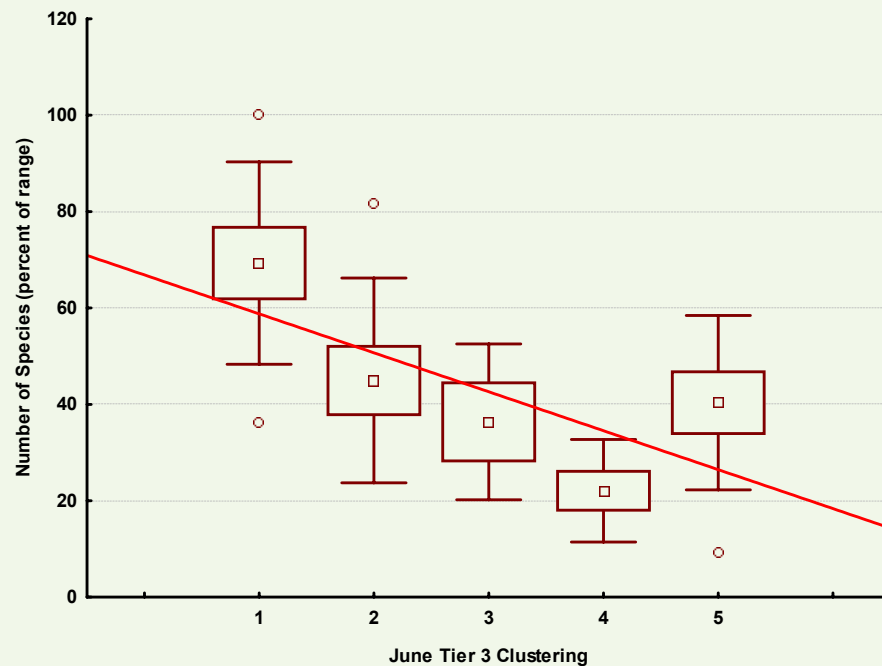
August Cluster Analysis Results



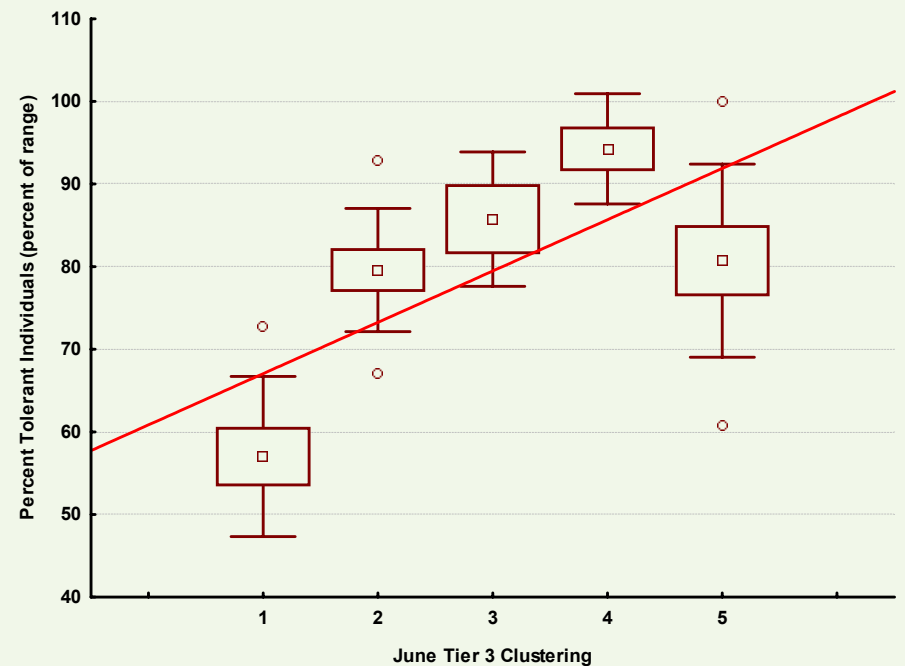
Validation of Biological Gradient

June Sampling

Number of Species



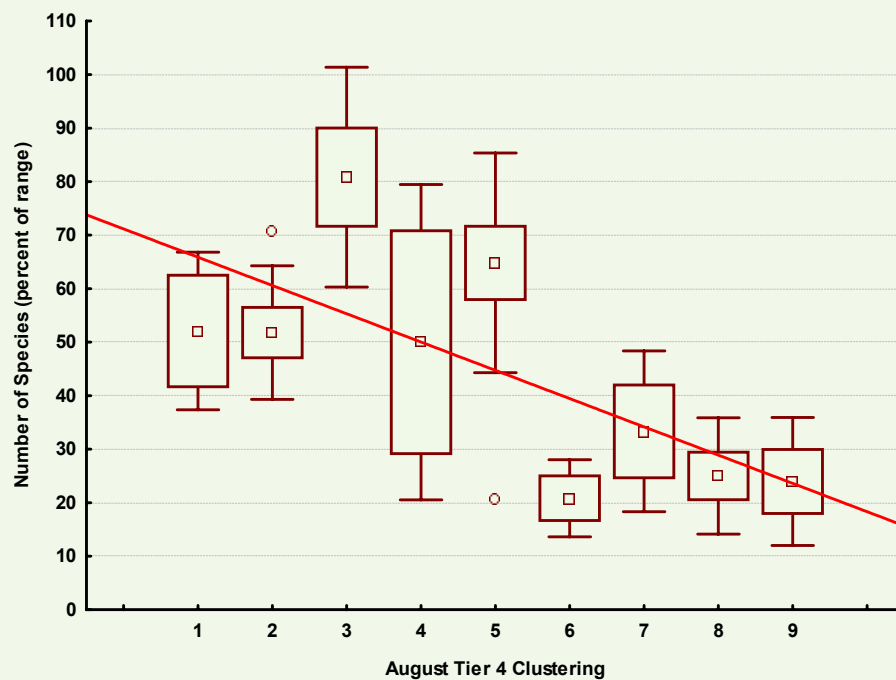
Percent Tolerant Individuals



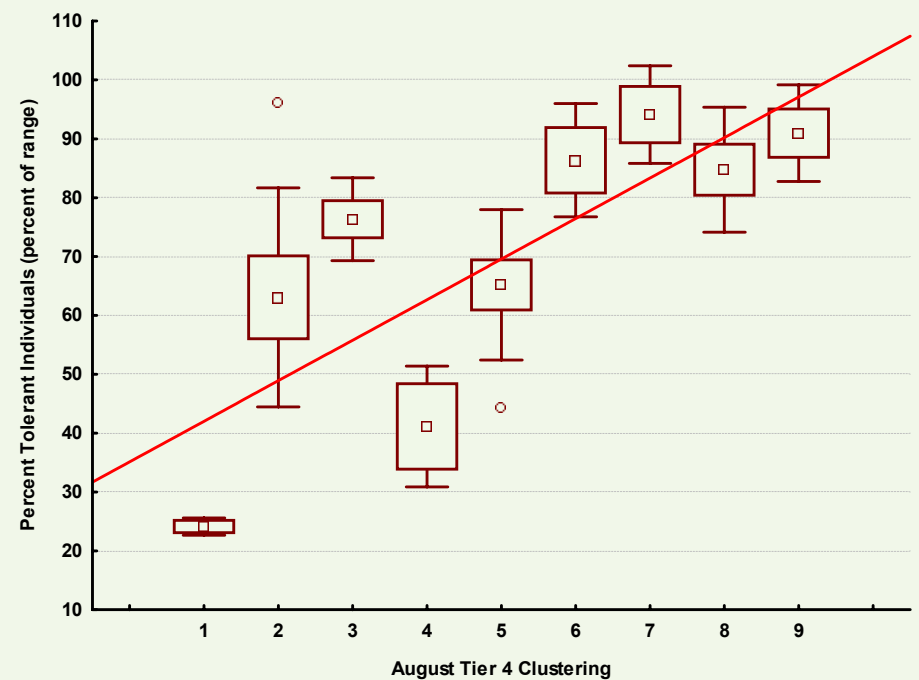
Validation of Biological Gradient

August Sampling

Number of Species



Percent Tolerant Individuals






June ANOVA

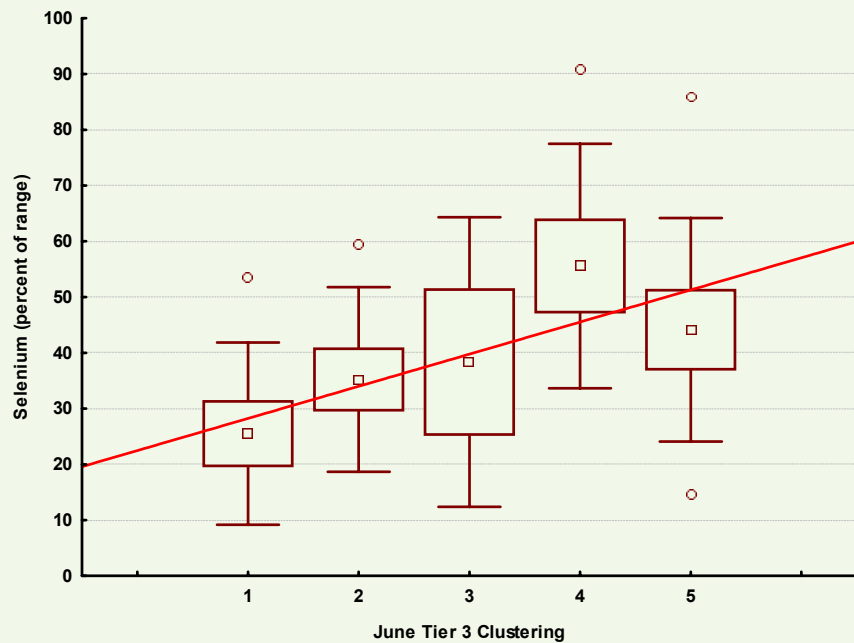
- Fish community structure were statistically predictive on six water chemistry and six habitat variables

Water Chemistry

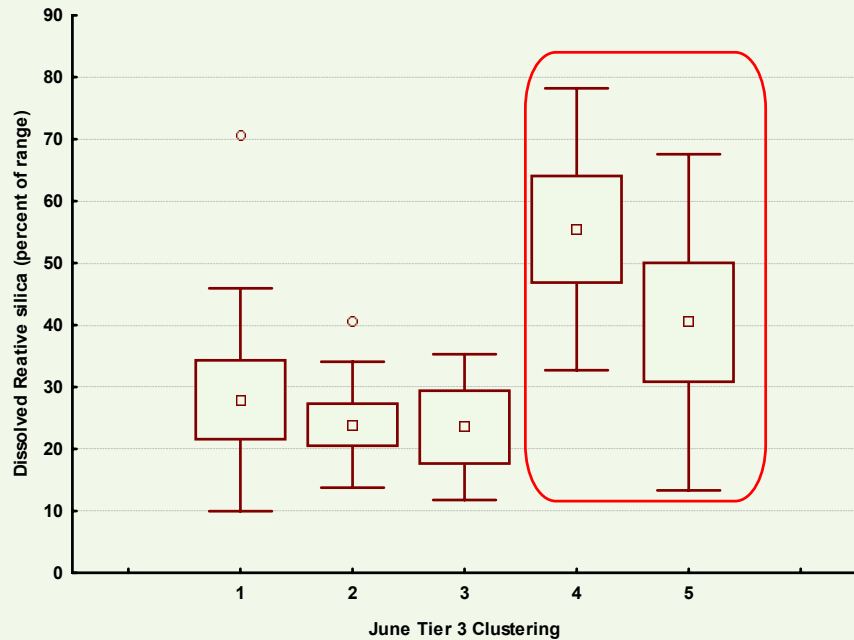
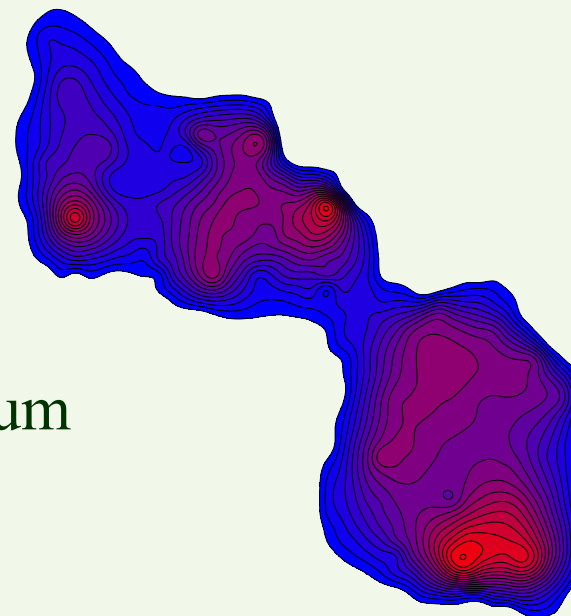
- Selenium
- Reactive Silica
- $\text{NO}_2 + \text{NO}_3 - \text{N}$
- Total Suspended Solids
- Total Solids
- Chemical Oxygen Demand

Habitat

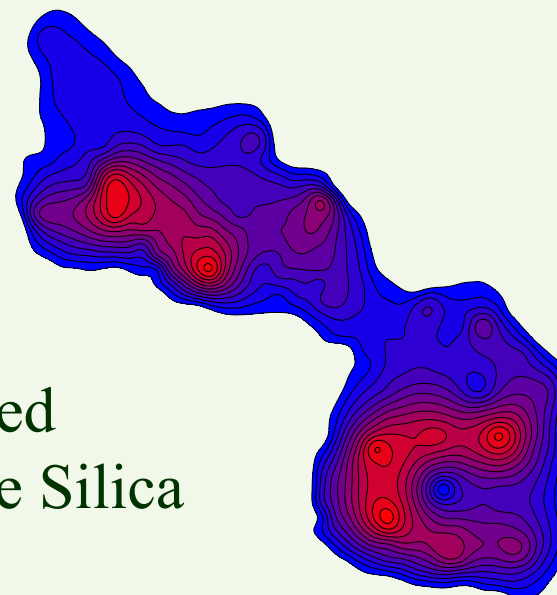
- Large Woody Debris
 - % Riffle Habitat
 - % Run Habitat
 - % Pool Habitat
 - Channel Morphology
 - Riparian Zone
- 

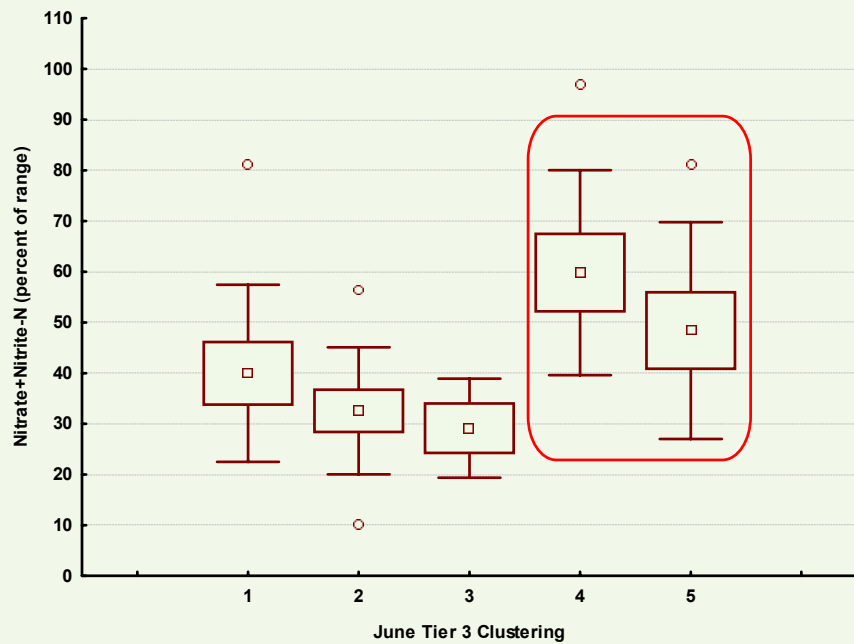


Selenium

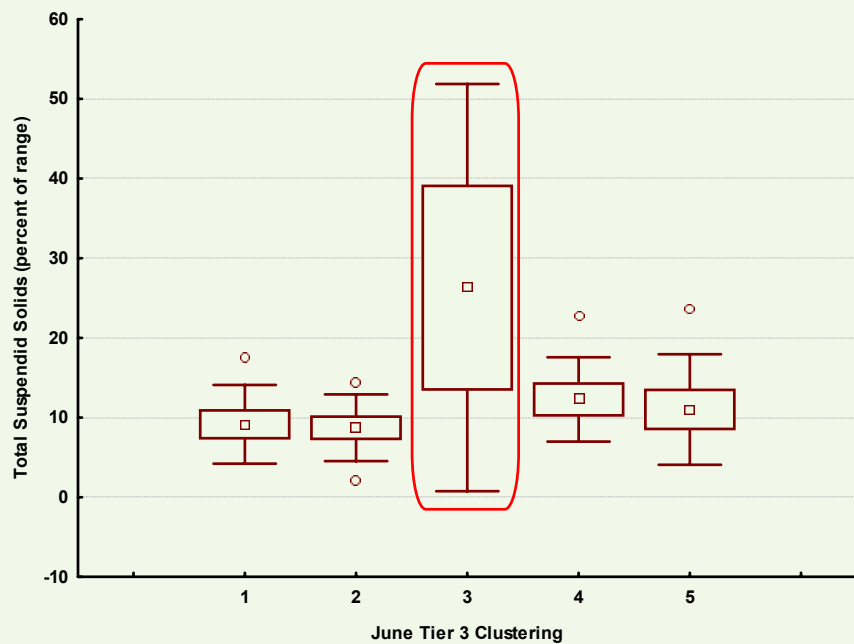
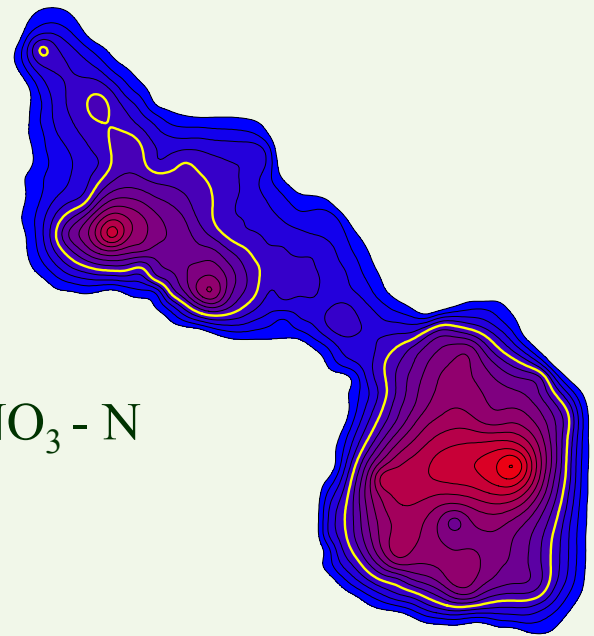


Dissolved
Reactive Silica

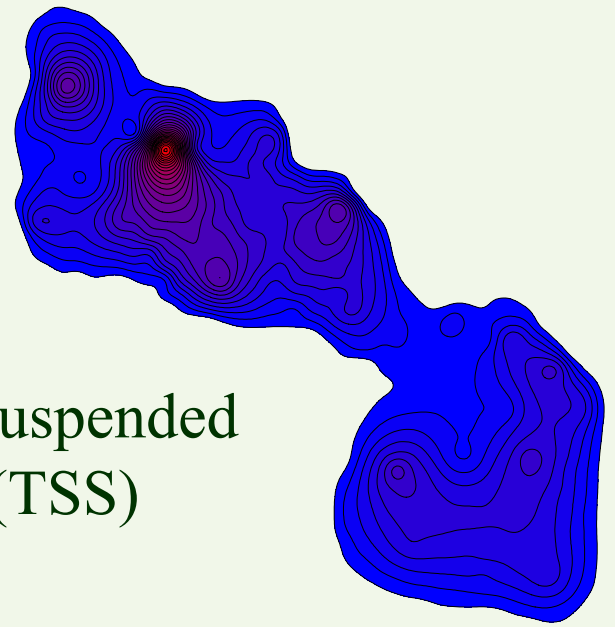


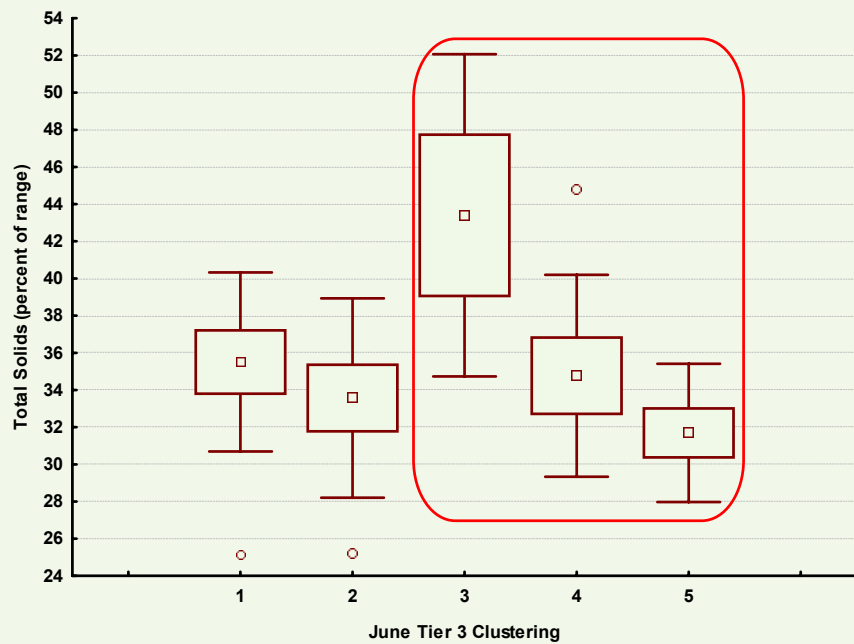


$\text{NO}_2 + \text{NO}_3 - \text{N}$

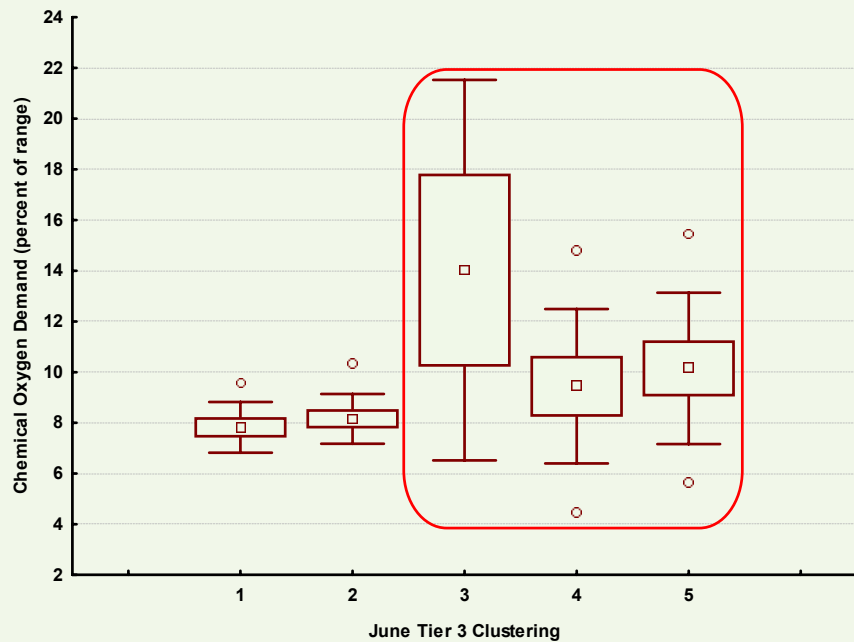
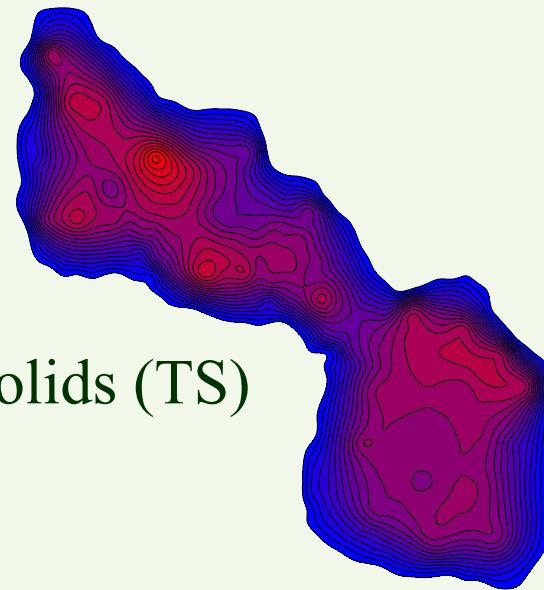


Total Suspended Solids (TSS)

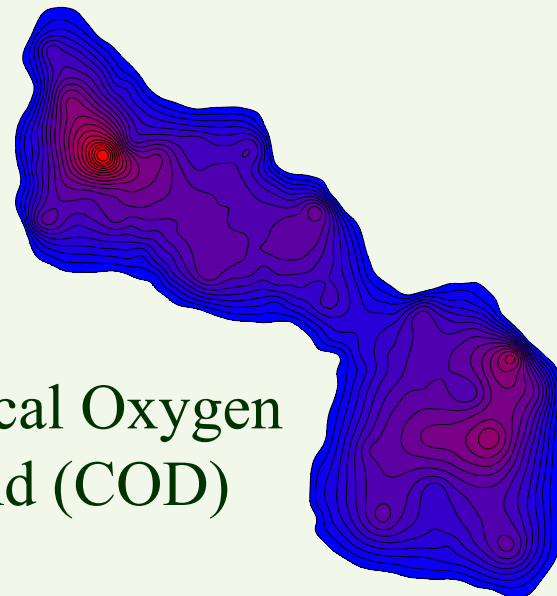




Total Solids (TS)



Chemical Oxygen Demand (COD)





August ANOVA

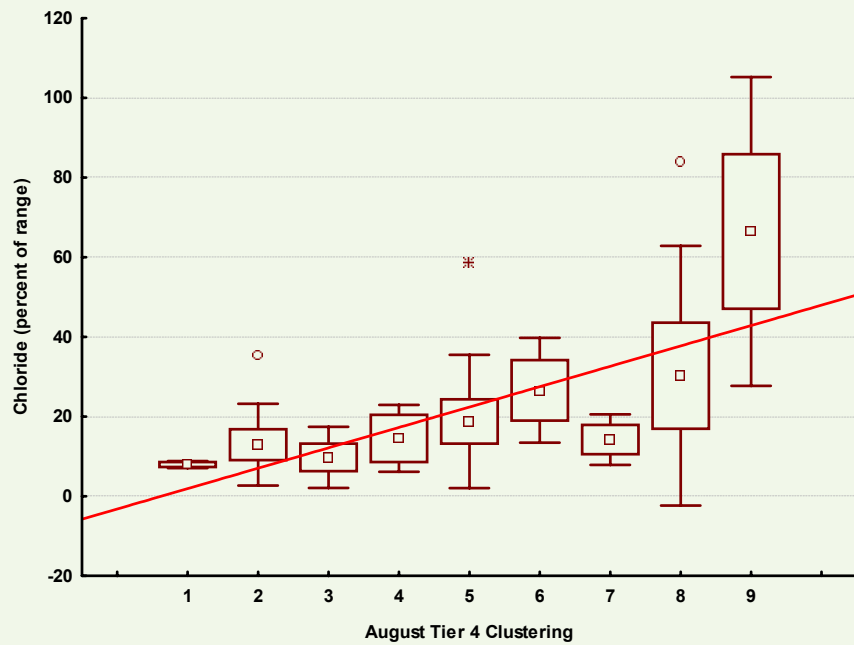
- Fish community structure were statistically predictive on five water chemistry and one habitat variable

Water Chemistry

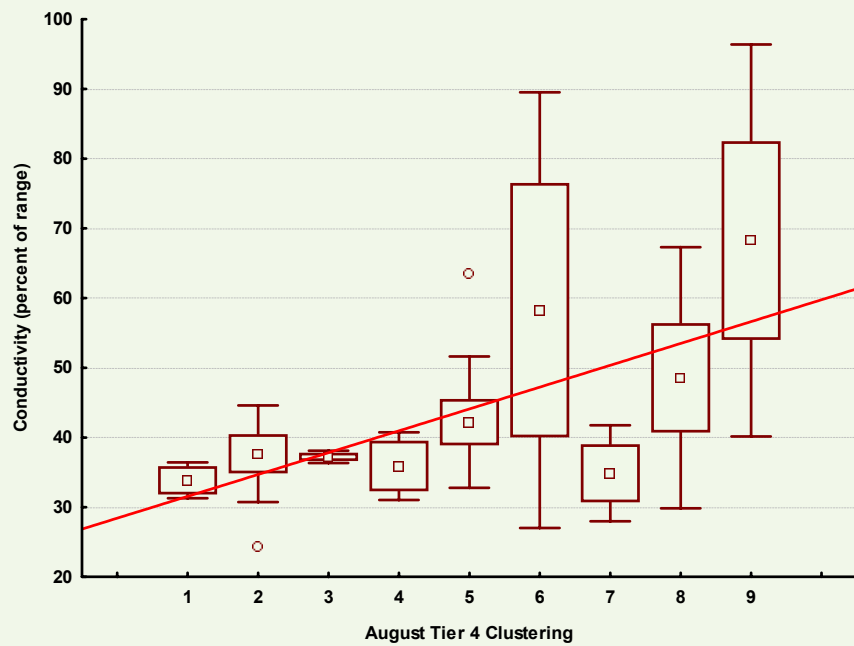
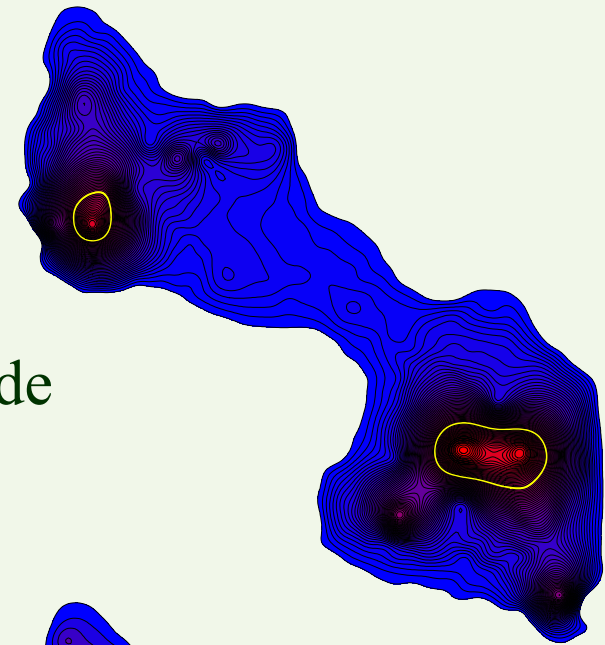
- Chloride
- Conductivity
- Barium
- Sodium
- Total Phosphorus

Habitat

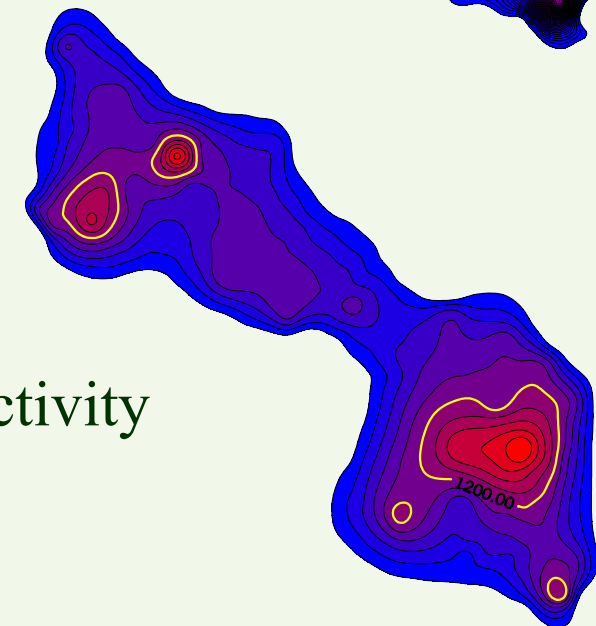
- Channel Morphology
- 

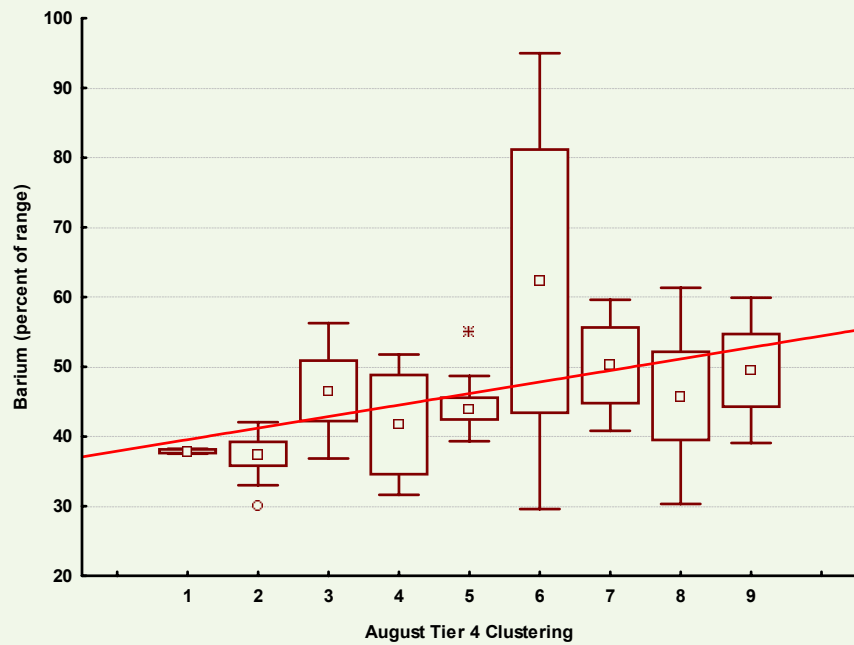


Chloride

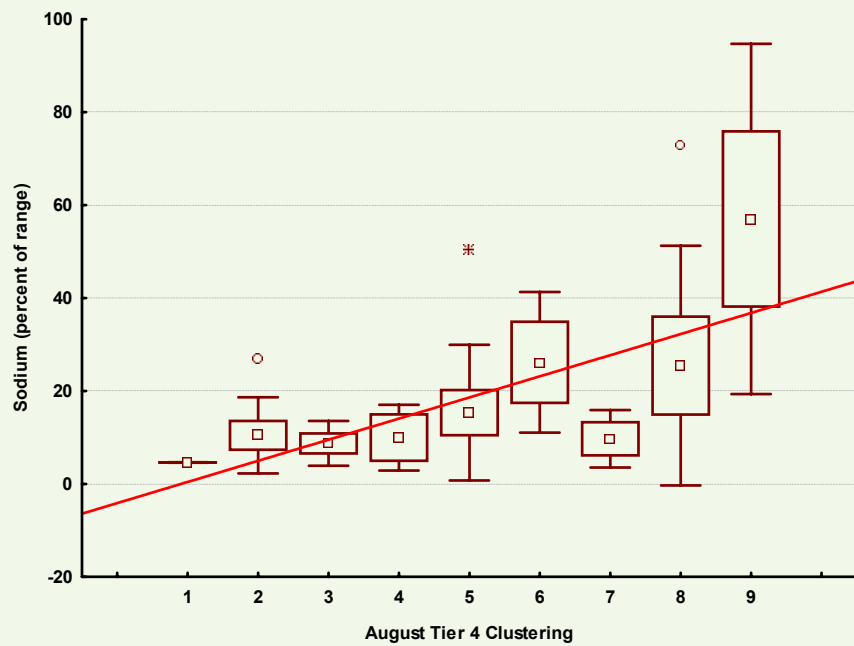
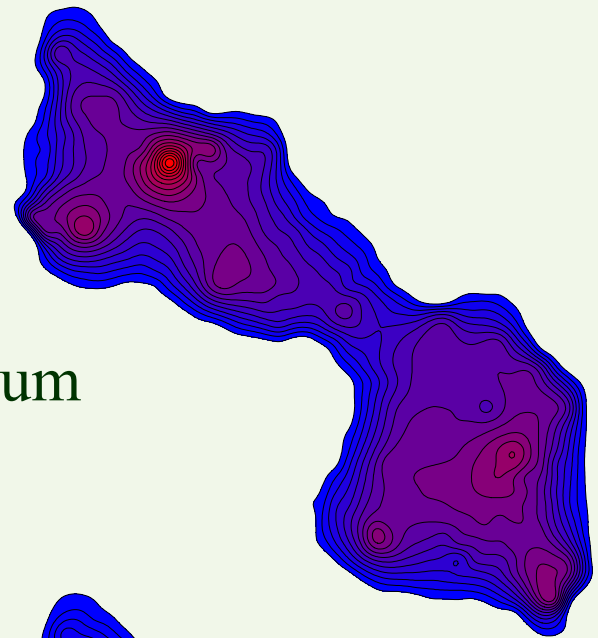


Conductivity

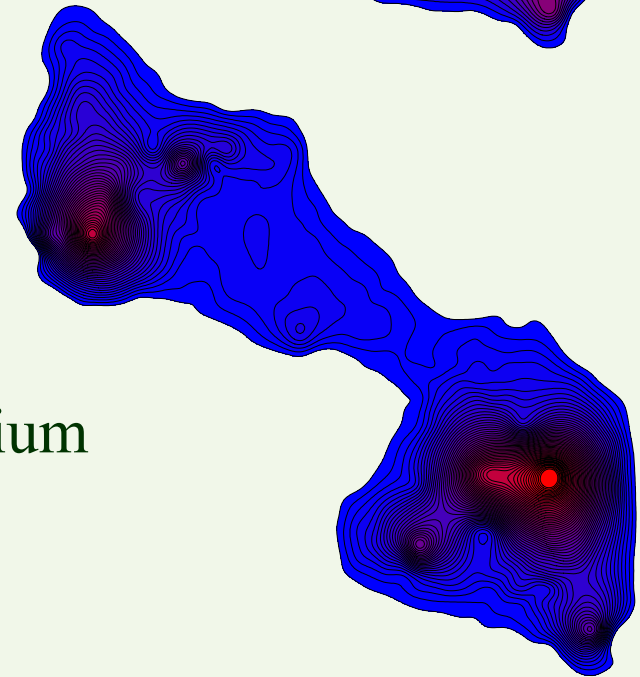


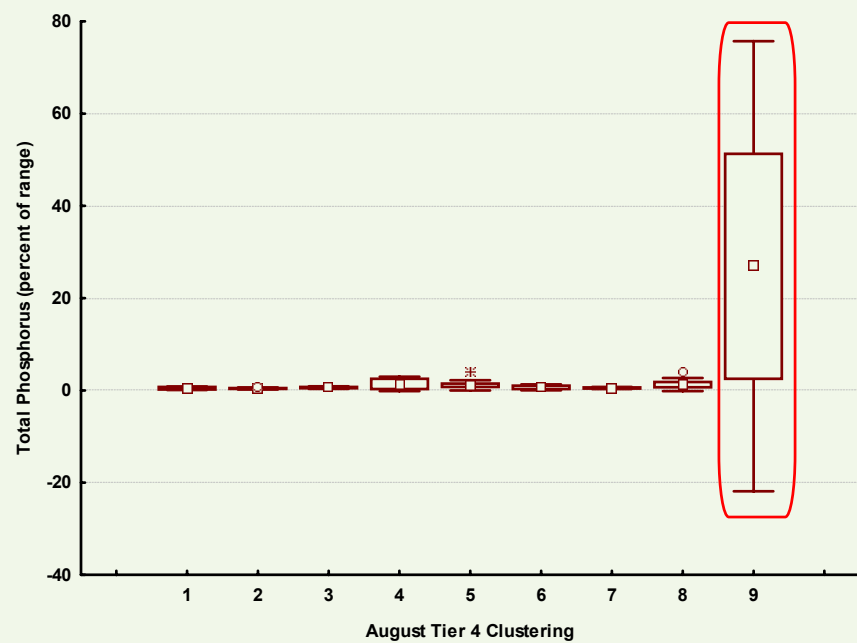


Barium

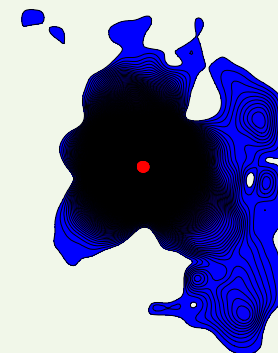
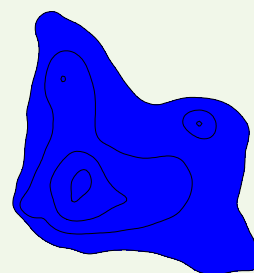


Sodium






Total Phosphorus





Conclusions

- Of the three chemical variables violating numeric criteria only chloride was predictive of the existing biological gradient
 - Chloride violated criteria at 2% of sites in June (1 location) and 9% of sites in August (5 locations)
 - Nitrogen ($\text{NO}_2 + \text{NO}_3 - \text{N}$) was pervasive throughout the watershed violating drinking water (at point of intake) criteria at 65% of sites sampled in June
 - An additional 10 chemical variables were found to be predictive of the biological gradient of which none violated existing aquatic life numeric criteria
- 



Acknowledgements

- Betty L. Ratcliff
 - Toxicology and Chemistry Section, IDEM, OWQ
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